NOAA FISHERIES

NW Fisheries Science Center

Ecosystem Considerations

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NOAA FISHERIES
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How well does the Center consider ecosystem and environmental factors affecting fish stocks and their assessments?

Outline: ecosystem and environmental factors

- What are assessments currently tasked with considering in the PFMC stock assessment TORs?
- What are we currently doing (or have done in the recent past) to address ecosystem and environmental considerations?
- Needs identified either in stock assessments or by the PFMC.

What are assessments currently tasked with considering in the PFMC stock assessment TORs?

- STAT responsibilities
  - Consult with ecosystem assessment scientists
  - Meeting with Integrated Ecosystem Assessment (IEA) teams
  - Evaluate alternative models and analyses
- SA Executive Summary
  - Review of environmental and ecosystem factors
  - Discuss assessment applications

What are assessments currently tasked with considering in the PFMC stock assessment TORs?

- SA Introduction - Ecosystem considerations
  - Ecosystem role and trophic relationships
  - Habitat requirements/preferences
  - Data on ecosystem processes that may affect stock or model parameters
  - Section content depends on:
    - Availability of data and reports from the IEA
    - STAT expertise
    - Whether ecosystem factors provide quantitative information
- SA History of modeling approaches
- SA Assessment Model

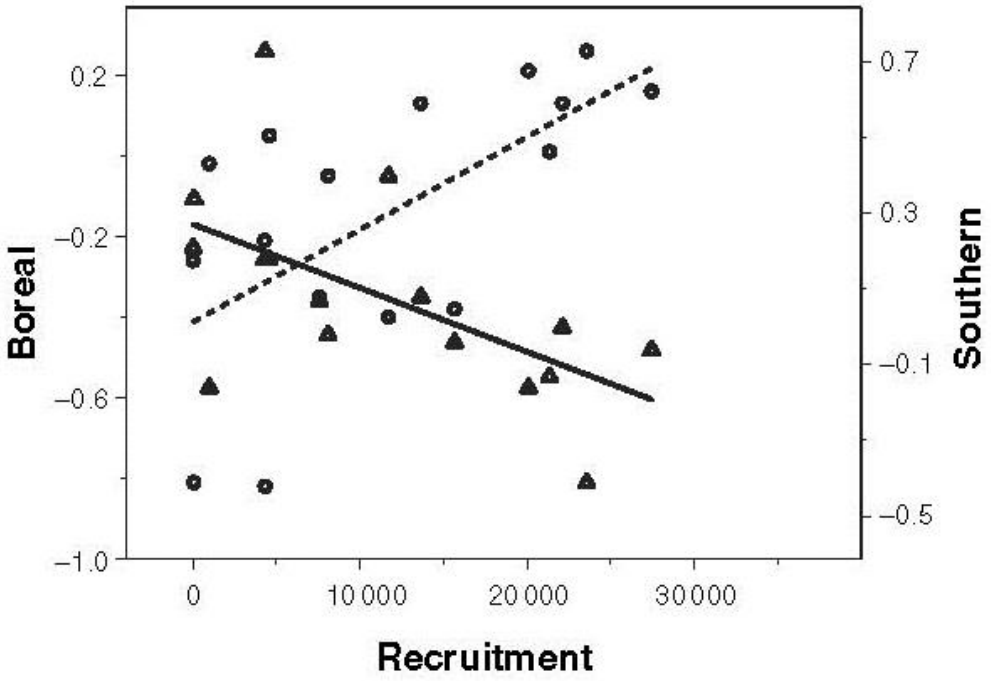
What are we currently doing (or have done in the recent past) to address ecosystem and environmental considerations?

- TORs
- Beta test and develop capabilities in SS3
- Assessments that have used environmental/ecosystem factors directly or indirectly
  - Sablefish SSH-recruitment relationship
  - Pacific hake time varying selectivity
  - Area specific assessments (environment, exploitation, data availability)
    - Cabezon, Lingcod, Chilipepper and Widow Rockfish es – recruitment, growth, maturity

Environmental drivers of U.S. west coast sablefish recruitment

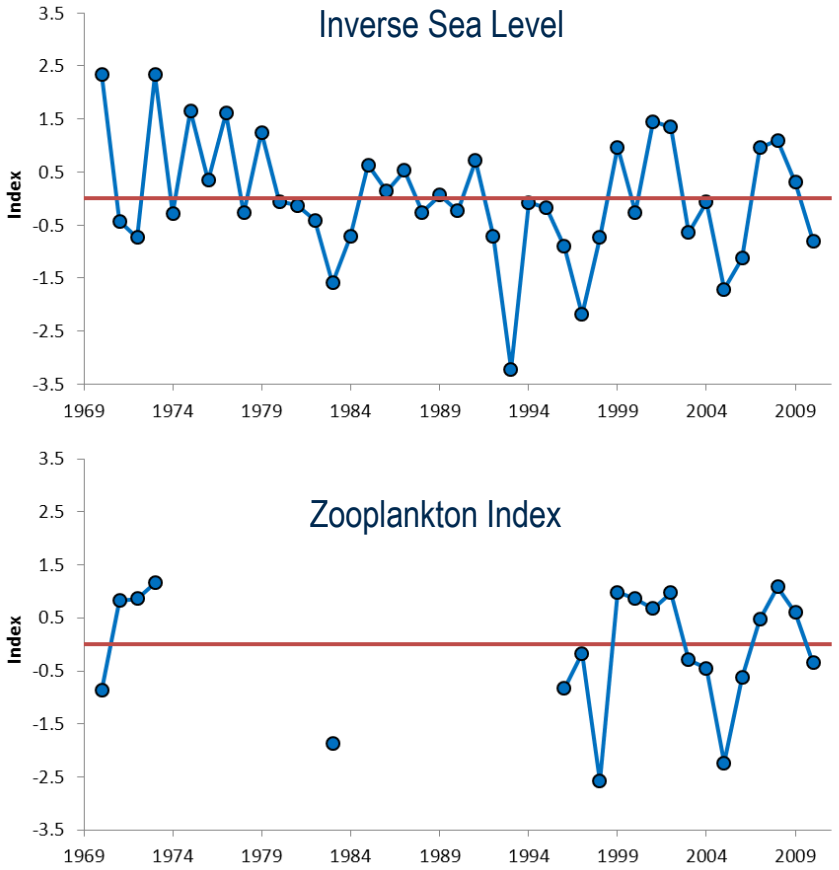
- Widely distributed, winter deep water spawners
- Pelagic larvae are offshore before migrating inshore to settle as juveniles

- Zooplankton abundance
  (Schirripa and Colbert, 2006)
- Mechanism: Feeding conditions during pelagic life stages drive recruitment
- Feeding conditions are indexed by SSH

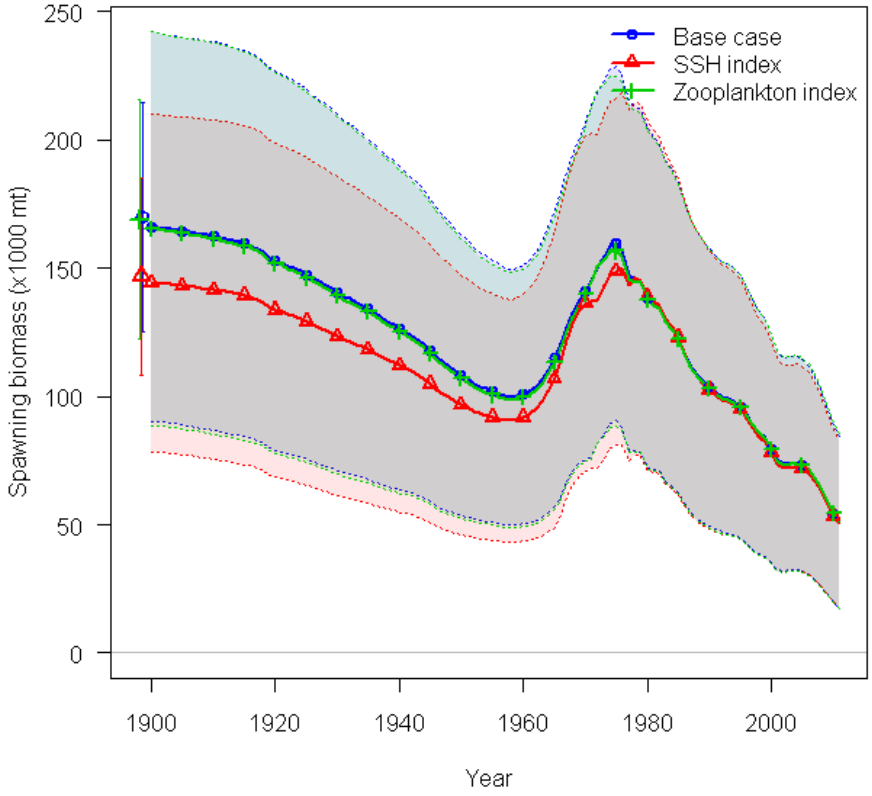


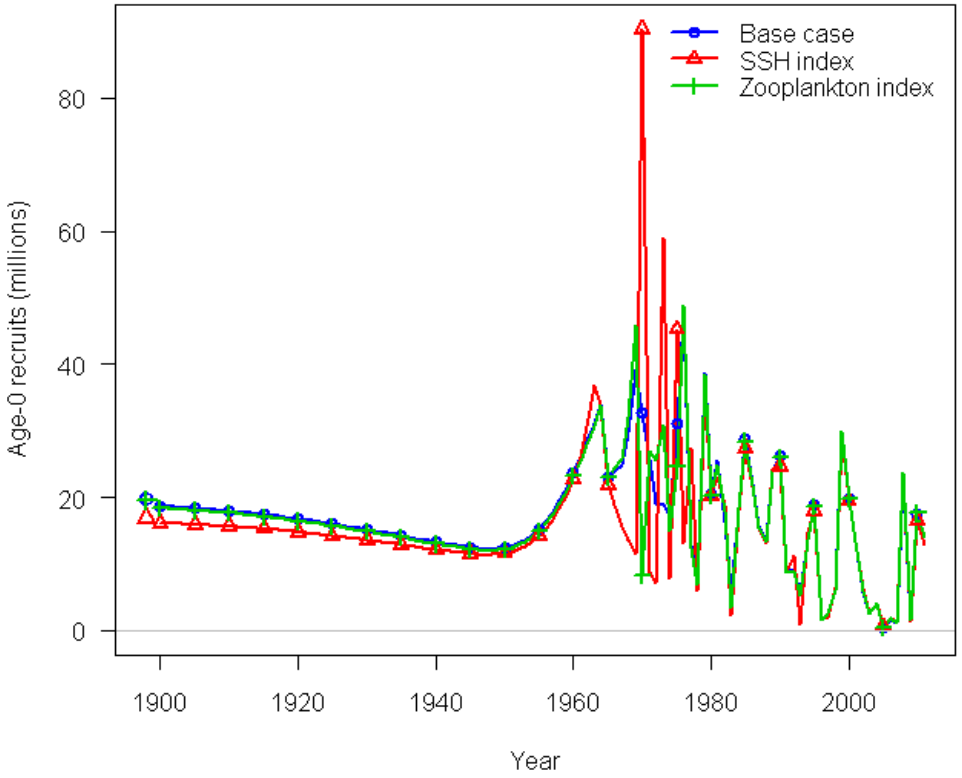
Stock Assessment Applications

- 2005, 2007, 2011 applications
- Continuing validation
  - Bootstrap, jackknife, and removal of recent values (Schirripa and Colbert 2006, Schirripa 2007)
  - Randomization tests (Stewart et al., 2011)
- 2007, 2011 stock assessments considered the April-June average sea level between Newport, OR and Neah Bay, WA.
- ~35% of the variance in recruitment explained



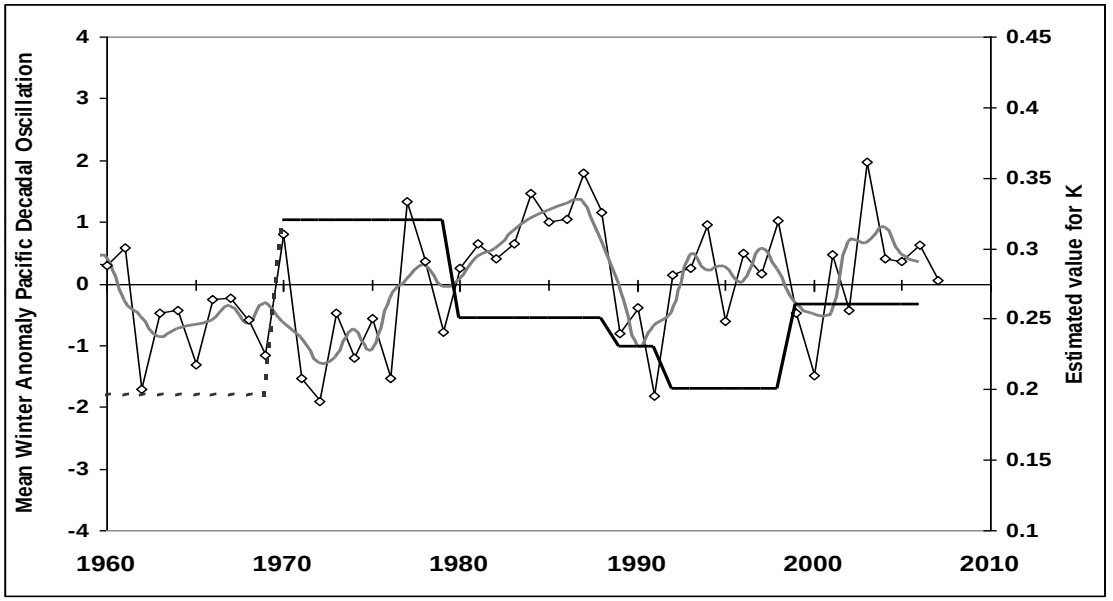
2011 Stock Assessment Results:
Sea level as a Survey Index of Recruitment

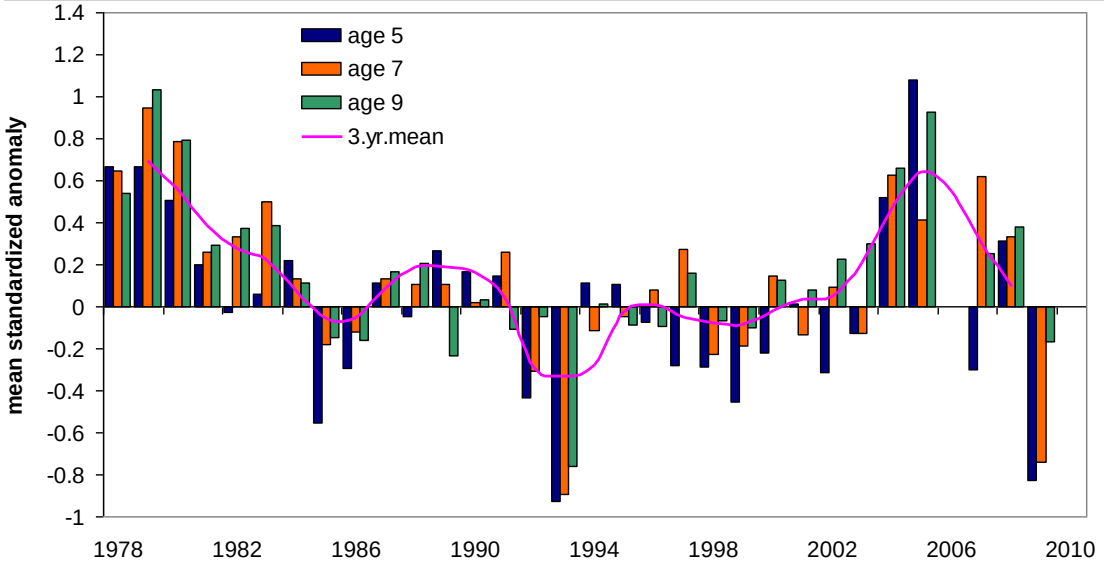




Chilipepper: Climate and Growth

- Weak correlation of growth rate (von Bert k) with mean winter PDO
- Assessment incorporates time-varying growth and climate indices



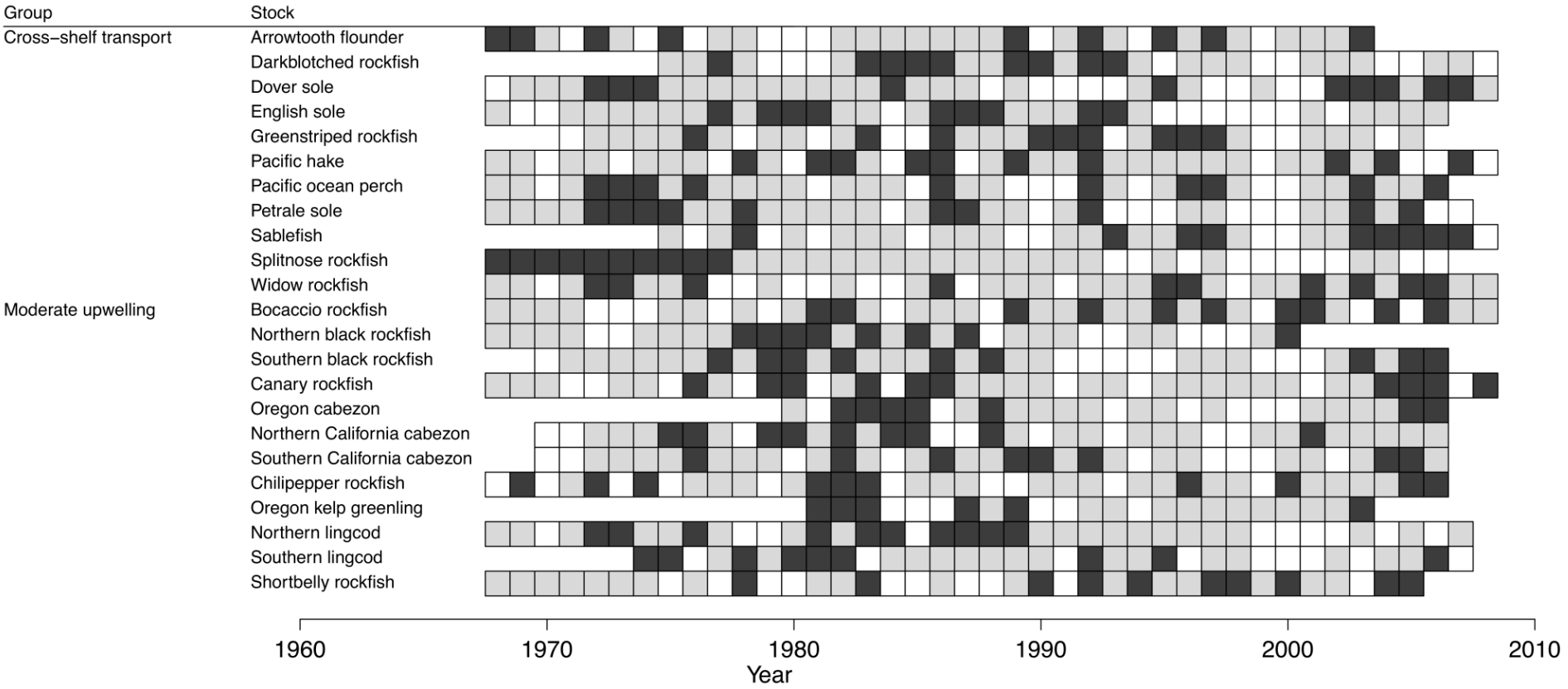


What are we currently doing (or have done in the recent past) to address ecosystem and environmental considerations?

- FATE funded research
  - Environmental drivers of groundfish growth (UW PhD student)
  - Environmental drivers of groundfish recruitment (Stachura et al. 2014)
  - Time varying growth in splitnose assessment (Black and Gertseva)
  - Chillipepper recruitment variability (Field)
  - Time-varying fecundity of rockfish (Field, Harvey)
  - Humboldt squid as an agent of climate-driven ecosystem interactions in the California Current (Field et al)
  - Incorporating Climate Driven Growth Variability into Stock Assessment Models: a Simulation-based Decision Table Approach (Thorson, Gertseva, Punt)

Bayesian hierarchical modeling of environmental drivers of recruitment synchrony

(Stachura et al. 2014)



Moderate coherence between exceptionally strong and weak year classes

Bayesian hierarchical modeling of environmental drivers of recruitment synchrony

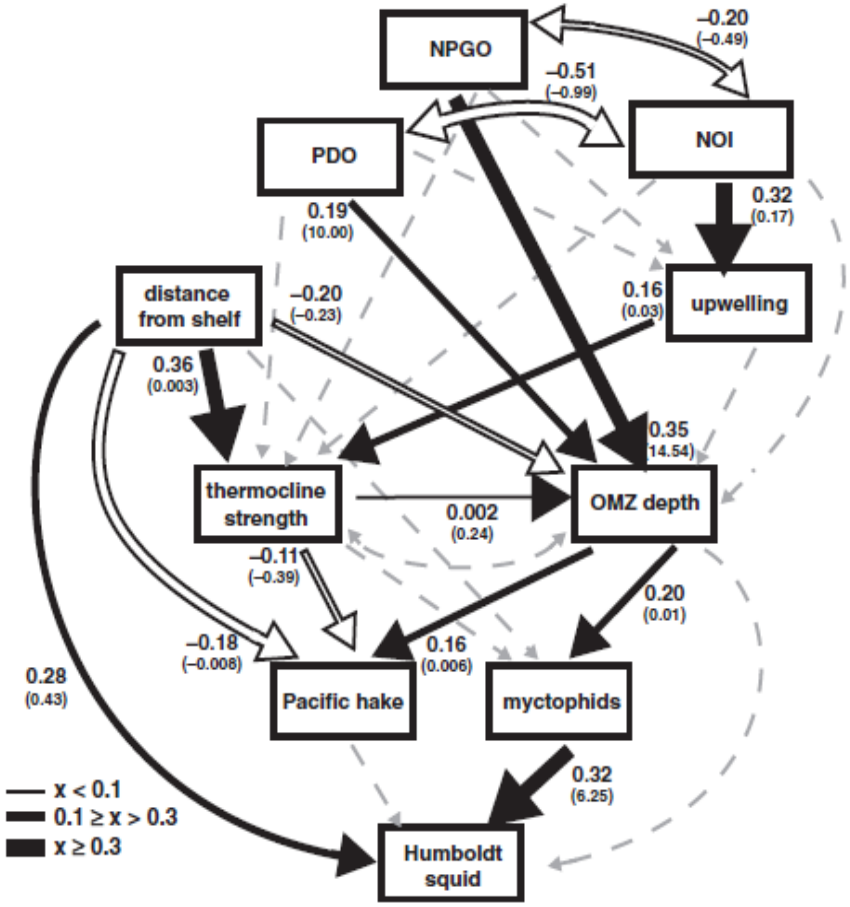
(Stachura et al. 2014)

- Best-fit model: San Francisco coastal sea level
- Higher recruitment
  - Anomalously high sea level the year before spawning
  - Low sea level the year of spawning
- Alongshore geostrophic flow

Combined climate- and prey-mediated range expansion of Humboldt squid

Stewart et al. Global Change Biology (2014) 20, 1832-1843

- Model Monterey Bay squid abundan
  - Shoaling of the Oxygen Minimum Zo is linked to range expansion.
- Mechanism
  - Habitat compression of mesopelagic fishes facilitates foraging opportunities.
  - Squid prey on Pacific hake
  - Data may inform estimates of additional mortality
  - Most prey are small, Ages 0-2 years



What are we currently doing (or have done in the recent past) to address ecosystem and environmental considerations?

- Additional Relevant Research
  - Methods for calculation of reference points for groundfish given decadal scale variability in recruitment (Haltuch et al. 2009)
  - Estimability of climate-recruitment relationships in stock assessments (Haltuch and Punt. 2011)
  - Relative magnitude of cohort, age, and year-effects on growth of exploited marine fishes (Thorson and Minte Vera, In Press)
  - Estimation of common trends in recruitment for US West Coast groundfishes (Thorson et al. 2013)

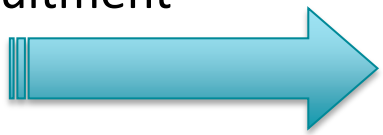
Model structure and BRP estimators: Advice for stock assessment

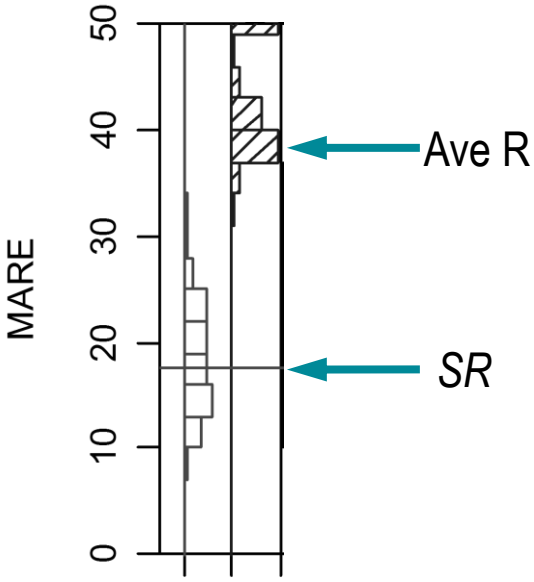
	True Condition	
	No Environmental Forcing of Recruitment	**Low Frequency Environmental Forcing of Recruitment**
Positive Test Result	Spurious Correlation (Type I Error)	Correct
Negative Test Result	Correct	Failure to Detect (Type II Error)

Model structure and BRP estimators: Advice for stock assessment

Base BRPs on the fit of the stock-recruitment relationship if:

- No environmental forcing of recruitment
- Short catch/survey time series





Base BRPs on average recruitment if:

- Low frequency forcing of recruitment
- Long catch/ survey time series

The method used to calculate BRPs impacts estimation ability more than stock assessment model configuration.

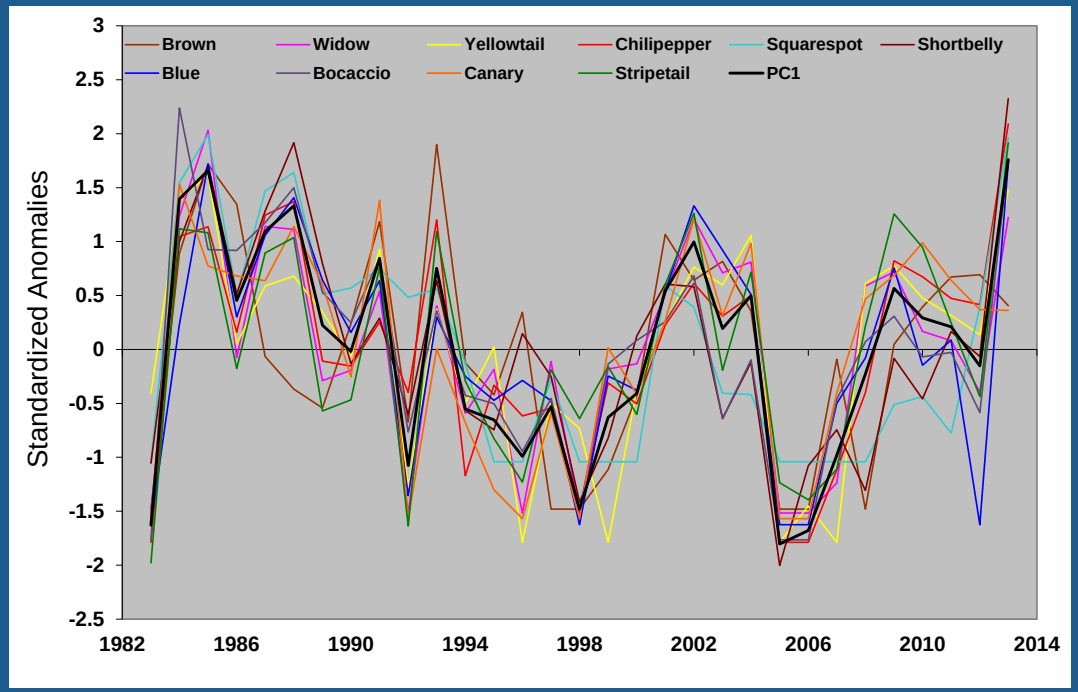
What are we currently doing (or have done in the recent past) to address ecosystem and environmental considerations?

- Additional Relevant Research
  - Hake distribution (Haltuch and Holt (DFO))
  - Sablefish MSE focusing on economics (Holland)
  - Variability in rockfish recruitment and ecosystem structure (Jarrod et al. 2012, Ralston et al. 2013)
  - Fisheries Management under Climate and Environmental Uncertainty: Control Rules and Performance Simulation (Punt et al. 2013)
  - Using IPCC-class models to assess the impact of climate on living marine resources (Stock et al. 2011)

Interannual variation in pelagic juvenile rockfish abundance

Variability in California Current Rockfish Recruitment (Ralston et al. 2013)

- Sea level anomalies preceding the survey are correlated with reproductive success.
- Alongshore flow (equatorward) anomalies following the spawning season are associated with elevated survival
- Poleward anomalies are associated with poor survival.

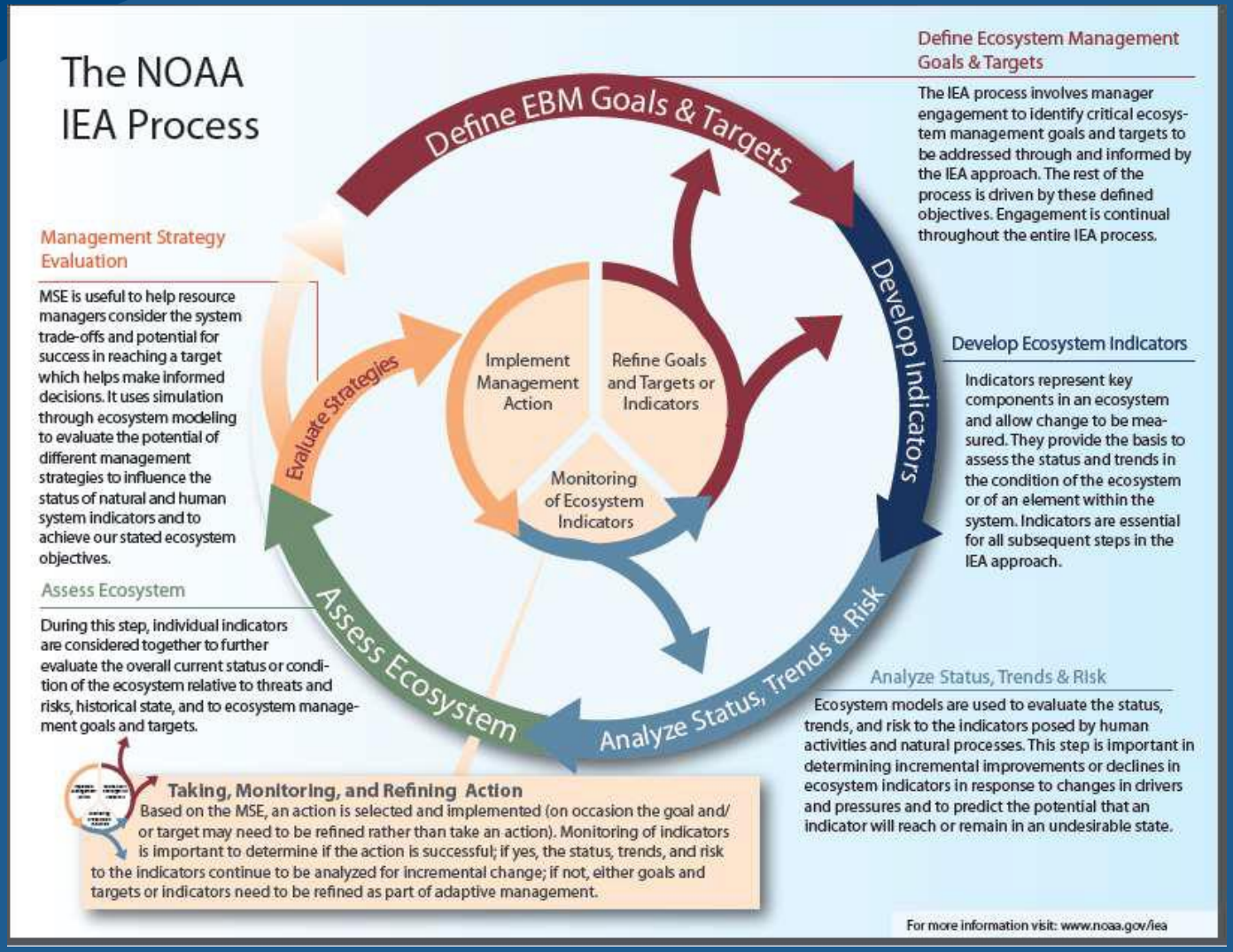


What are we currently doing (or have done in the recent past) to address ecosystem and environmental considerations?

Bringing ecosystem information into the Council process

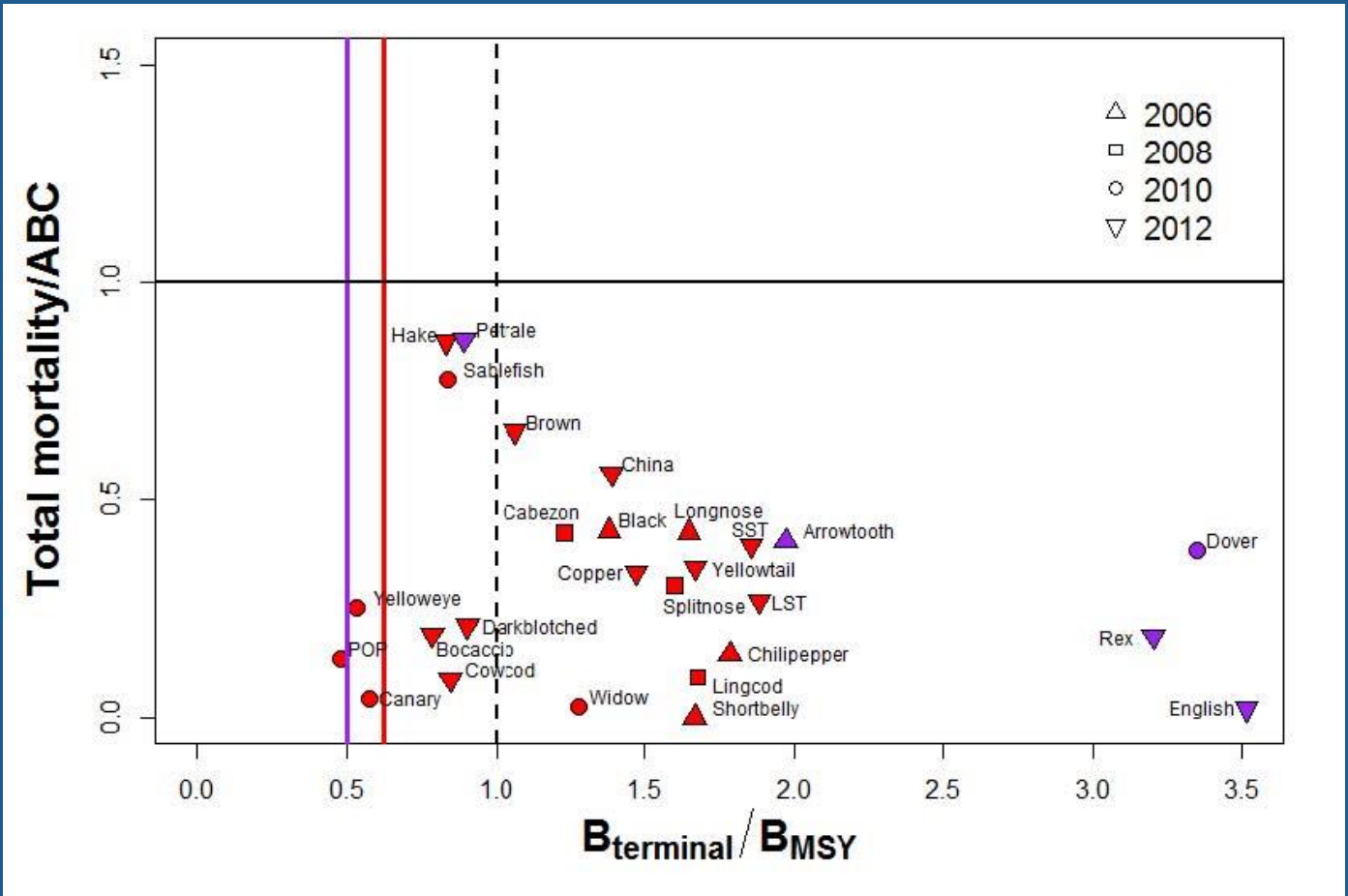
- Collaborations between the NMFS NWFSC and SWFSC
  - CC Integrated Ecosystem Assessment
    - Assessment group contributes to groundfish section
  - Annual State of the California Current Ecosystem Report
  - PFMC Fishery Ecosystem Plan

NOAA Integrated Ecosystem Assessment Program: California Current http://www.noaa.gov/iea/



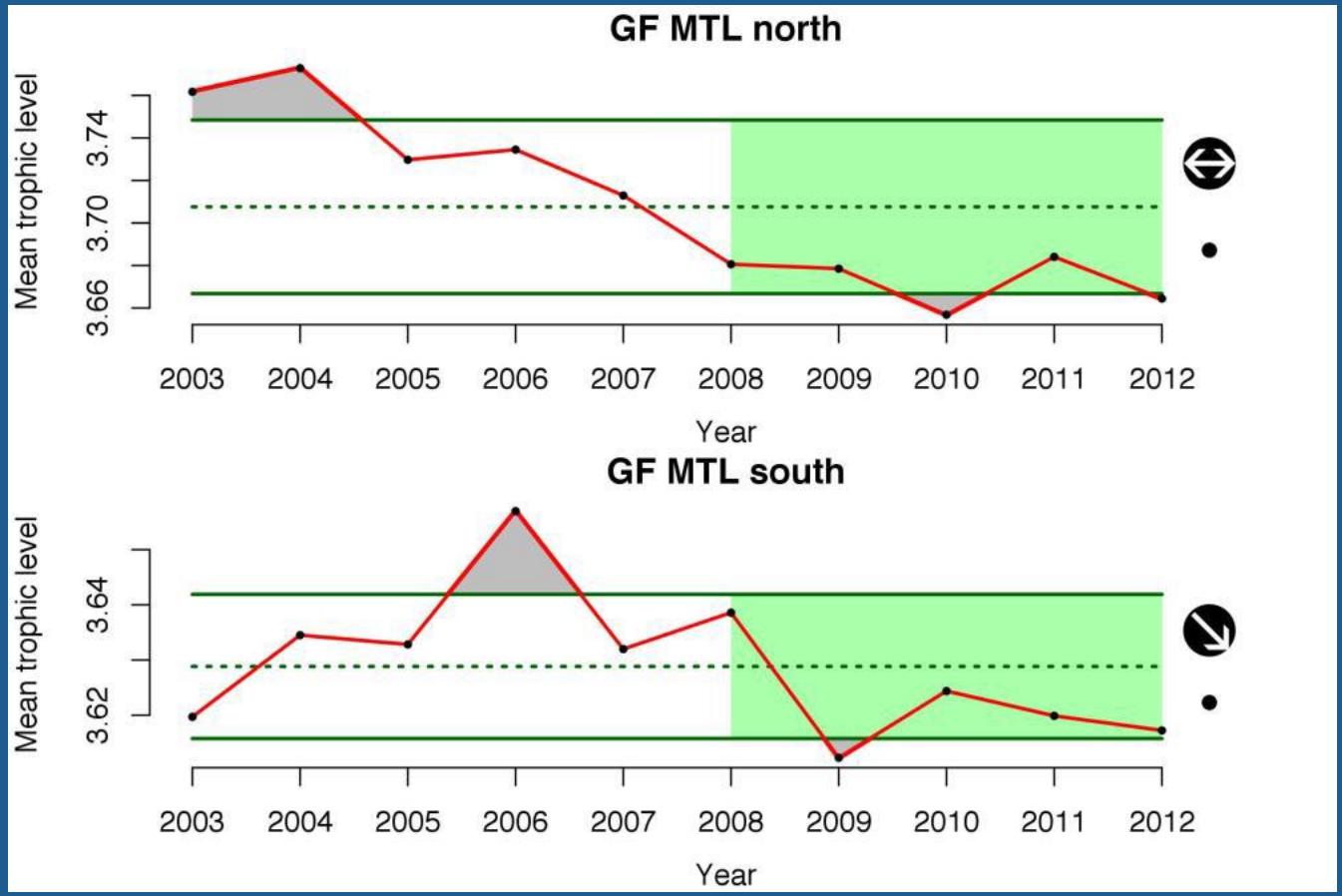
CC Ecosystem Report: Status and trends plots

3.5 Groundfish: Stock Status Relative to Biological Reference Points



CC Ecosystem Report: Status and trends plots

3.6 Mean Trophic Level of West Coast Groundfishes



RESEARCH AND DATA NEEDS 2013

Section 2 ecosystem based fishery management & Section 5.4 Groundfish FMP

- Estimate total catch for target and non target species and their prey and predators.
- Identify indicators for recruitment, growth, spatial availability, and overall California Current Ecosystem (CCE) productivity.
- Examine the influence of predator-prey relationships (stomach analyses), competition, and disease for FMP species.
- Environmental and population density drivers of time-area differences/changes in population structure and parameters.
- Investigate relationships between the stock availability, fecundity, distribution, recruitment, growth, migration, and natural mortality with climate / oceanographic conditions (e.g. changes in water masses, temperature fronts, and prey abundance).

RESEARCH AND DATA NEEDS

Section 2 ecosystem based fishery management & Section 5.4 Groundfish FMP

- The influence of climatic/oceanographic conditions on the population dynamics.
  - Evaluate the efficacy of incorporating environmental factors within the current stock assessment modeling framework (Stock Synthesis 3).
    - Previous methods work on recruitment
  - Model effects of climate forcing and other ecosystem interactions (e.g., trophic interactions) on productivity.
- Determine the origin of benthic juvenile groundfish and formulate hypotheses for larval dispersal and stock structure.
- Differences in age and length compositions between trawlable and untrawlable areas.

PFMC Ecosystem Fishery Management Plan

6 Bringing Cross-FMP and Ecosystem Science into the Council Process

6.1 Bringing More Ecosystem Information into Stock Assessments

- Recognizing the status of stock assessments as both frequently conducted and heavily used Council-related science, the SSC recommended in September 2010: ". . . that a subset of stock assessments be expanded to include ecosystem considerations. This would likely require the addition of an ecologist or ecosystem scientist to the Stock Assessment Teams (STATs) developing those assessments.

Strengths

- Partnerships with university faculty and students
- FATE
- Products used by the PFMC
- Conservation Biology Division, Ecosystem Science Program
  - Works on many aspects of ecosystem considerations

Challenges and Solutions

- Funding
- Dedicated Personnel
  - Hire FATE FTE
  - Add ecologists or ecosystem scientists to the Stock Assessment Teams
- Space
- Ship time
  - Process studies/data collection for investigation of hypotheses

Challenges and Solutions

- Lack groundfish-focused, process-oriented, field studies to investigate many of the research questions previously highlighted
  - Programs similar to FOCI and BASIS at the AFSC could aid in investigating hypotheses.
  - Hypotheses for some species could be culled from the literature but many of these have not been re-tested.